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A GEOLOGICAL RECONNAISSANCE IN HAITI  
A CONTRIBUTION TO ANTILLEAN GEOLOGY

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INTRODUCTION

The following paper is the result of observations made during several months' work in Haiti during the spring and summer of 1918 while engaged on private work. The localities visited for

economic purposes were so widely scattered that the writer was forced to cover a large part of Haiti. Observations made are, therefore, somewhat scattered but a fairly accurate geologic section from the south coast to the north range of mountains is the result. Many of the problems could be only noted and left for future work which the writer expects to undertake.

Haiti has received but scant attention from geologists. Tertiary fossils have been collected by several people, not geologists, and have been described in the literature from time to time. L. G. Tippenhauer, a civil engineer of Port-au-Prince, has published a series of maps and papers on Haiti.<sup>1</sup> His efforts deserve great commendation, though his stratigraphy leaves much to be desired. His text is largely geographical. His geologic mapping in so far as contacts go is generally accurate but similar formations are not always so recognized. His topography is excellent and his delineation of trails and roads uncanny in its accuracy.

With such maps available, and with a large part of Haiti, north of Port-au-Prince, of open and bare country and with excellent continuous rock exposures, the region probably is more ideal for field observation than any of the other islands. The several formations are here developed in what is doubtless their greatest thickness, and a cross-section of Haiti is a fairly complete study in Antillean geology.

In the neighboring republic of Santo Domingo practically no work has been done since the early work of Gabb,<sup>2</sup> excepting the recent work of Maury on the Tertiary faunas of the Rio Yaqui del Norte.<sup>3</sup>

The writer wishes to acknowledge the free use of the Tippenhauer maps and to use this means of expressing his gratitude to the enlisted men and officers of the U.S. Marine Corps who are stationed as officers of the Gendarmerie d'Haiti in the larger villages of the

<sup>1</sup> "Beiträge zur Geologie Haitis," *Peterm. Mitt.*, Bd. 45, pp. 25-29, 153-55, 201-4, 1899; Bd. 47, pp. 121-27, 169-78, 193-99, 1901; Bd. 55, pp. 49-57, 1909.

<sup>2</sup> W. M. Gabb, "On the Topography and Geology of Santo Domingo," *Trans. Am. Phil. Soc.*, XV (1873), 49-260.

<sup>3</sup> C. J. Maury, "Santo Domingo Type Sections and Fossils," *Bulletins Am. Pal.*, Nos. 29, 30, 1917; and "Santo Domingan Paleontological Explorations," *Jour. Geol.*, XXVI (1918), 224-29.

country. Their hospitality and assistance makes traveling in that country a real pleasure, where otherwise it might be anything but such.

#### TOPOGRAPHY

The Gran Cordillera of the island, which attains its greatest development in Santo Domingo, forms in Haiti the north range, one of three well-defined, generally parallel, ranges in the latter country. The north range forms the north peninsula of Haiti and if continued west and east from Santo Domingo, forms the Cordillera of Cuba and Porto Rico, respectively. In Haiti the highest elevation attained by this range is about 1,500 meters, while in Santo Domingo it attains in Loma Tina an elevation of over 3,100 meters, the highest peak of the Antilles.

The central range, called the "Chaîne des Mateux," extends from the west coast on the south of St. Marc to the Caribbean Sea in Santo Domingo, and attains an elevation of about 1,700 meters. These two ranges, which trend generally S. 60°-70° E. are connected by the range of the Montagnes Noires, which trends S. 45° E. and attains an elevation of 1,500 meters. Between this latter and the north range is the central plain of Haiti, which drains, not to the east, but by a deep cut through the Montagnes Noires to the west.

The south range, forming the south peninsula, attains, in the Montagne de la Selle, an elevation of about 2,700 meters, the highest point in Haiti. This range trends nearly east and west.

Between the south and central ranges and extending from the Bay of Port-au-Prince to the Bay of Barahona in Santo Domingo is a depression about fifteen to twenty kilometers wide, bounded along its entire length by the precipitous faces of the ranges on either side. Much of this depression is below sea-level and contains two lakes, both below sea-level but at different elevations. The writer expects to present a paper at some future time on this rather unique locality.

With the exception of the south range the mountains of Haiti are generally bare in appearance and a large portion of the north-western part of the country is even quite arid. Valleys are generally fertile. The central plain is generally open grass-covered

country and in its southern part, where erosion has dissected it, presents in places the appearance of "bad" lands.

## STRATIGRAPHY

### A. PRE-TERTIARY ROCKS

*Old Complex.*—The Gran Cordillera of Santo Domingo consist essentially of a series of metamorphosed shales, sandstones, and conglomerates with extensive areas, or belts, of syenite. Gabb<sup>1</sup> called the metamorphosed series the Sierra group. Most of these sedimentary rocks are highly schistose. The structure, where decipherable, is complicated, forming even fan folds. Structural axes are parallel with the axis of the range.

These rocks are exposed over much of the north range of Haiti and generally lie on either side of a central intrusive belt. Tiphpenhauer's mapping of these areas is generally correct. Smaller areas of these rocks occur in valleys cut in the range of the Montagnes Noires. The age of these rocks is unknown. Gabb<sup>2</sup> called them Cretaceous, and Tiphpenhauer, Eocene. Both are probably wrong. The limestones from which Gabb collected *Ammonites* in Santo Domingo are undoubtedly unconformable with the schistose series. P. Frasar as early as 1888 argued an Archean age for these rocks.<sup>3</sup> The same series appear in Cuba and there form the base for all subsequent formations. In Porto Rico, Berkey's "Older Series,"<sup>4</sup> which he calls Cretaceous, are without doubt the same as the Haiti-Santo Domingo rocks though less metamorphosed. Some of the limestones and tuffs described by Berkey, especially his Coamo limestone, may be Cretaceous and correspond to Gabb's Cretaceous. Berkey's cross-section shows this Coamo member in such position that there may well be an unconformity at its base. Gabb apparently found a limestone member in the schist series and near by he found a limestone containing *Ammonites* and still in the same vicinity he found great thicknesses of limestone which are without

<sup>1</sup> *Op. cit.*, p. 83.

<sup>2</sup> *Op. cit.*, p. 87.

<sup>3</sup> *American Geologist*, XXI (1898), 250 (citing earlier statement).

<sup>4</sup> C. P. Berkey, "Geological Reconnaissance of Porto Rico," *New York Acad. Sci., Annals*, XXVI (1915), 1-70.

doubt Tertiary and which flank the entire south face of the north range, and in attempting to correlate these three he found it puzzling.

*Cretaceous*.—Tippenhauer<sup>1</sup> described a formation in Haiti of undoubted Cretaceous age, similar to part of the Cretaceous series of Jamaica. This locality has not been visited by the writer. It is thought highly probable that Cretaceous rocks exist in the south peninsula. Isolated areas of sandstones, shales, and limestones occur in this region, especially between Leogane and Jacmel, where the remnants are engulfed in late Tertiary intrusives and are generally metamorphosed (see Plate V, Section B). In this same section on the north flank of the hills is exposed a considerable thickness of tuffs which correspond in character with the Cretaceous series of Jamaica.

In the Monti Cristi Range of Santo Domingo Gabb<sup>2</sup> found *Orbitoides*. There is probably present there an upper Cretaceous formation of sandstones and shales, possibly the equivalent of the Richmond of Jamaica, which he failed to differentiate structurally from the overlying Miocene.

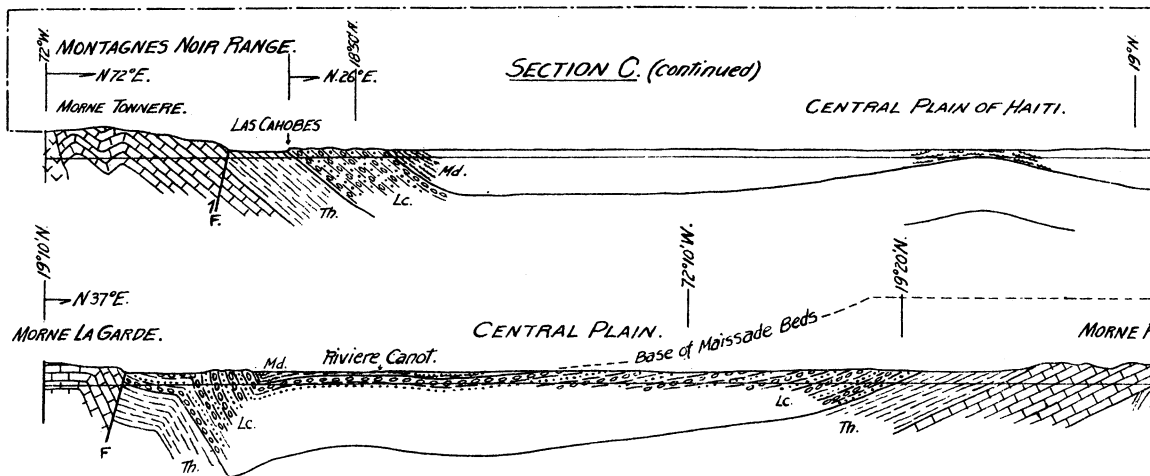
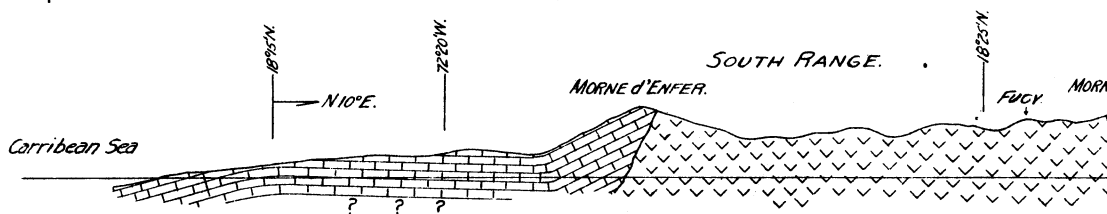
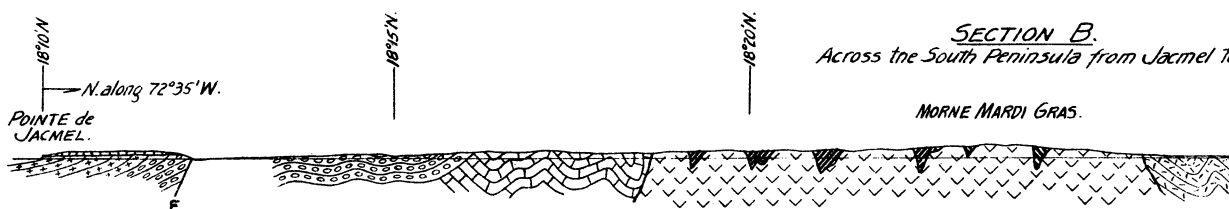
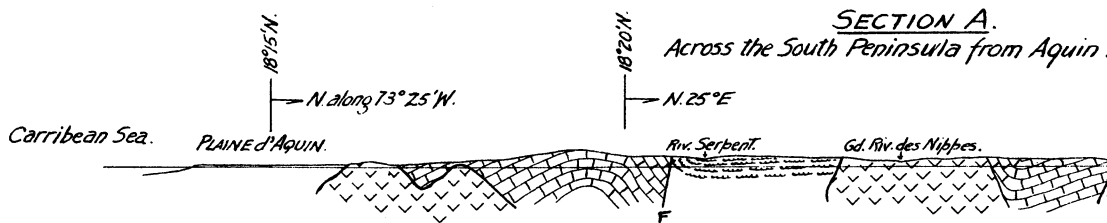
#### B. EARLY TERTIARY LIMESTONES

The several thick formations of limestone in Haiti have not been differentiated and there are several problems connected with them which are worthy of future work. With the exception of small areas of volcanic or intrusive rocks the entire central range, the Montagnes Noires, and a large belt along the south side of the north range are of limestone. Great thicknesses are developed and owing to continuous exposures the entire series can be carefully studied. From casual observation the series seems to consist of a basal member with considerable sandstone and above this a great thickness of very compact, light-gray or white, foraminiferal limestones, often very finely bedded but generally massive, and with intercalated beds of coralline limestone (Figs. 1 and 2).

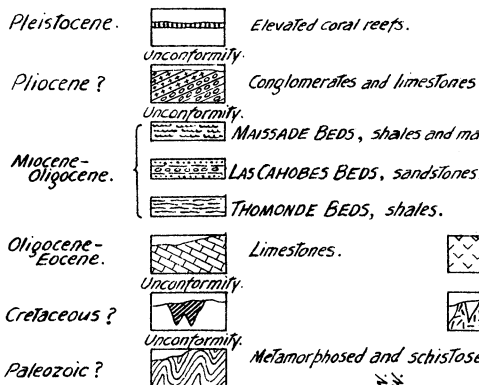
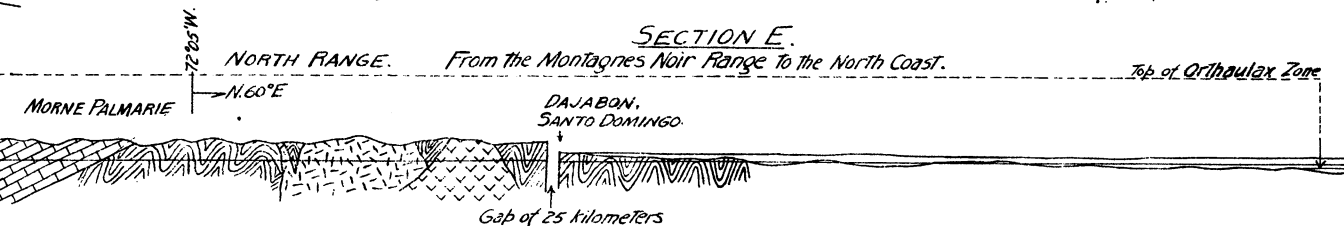
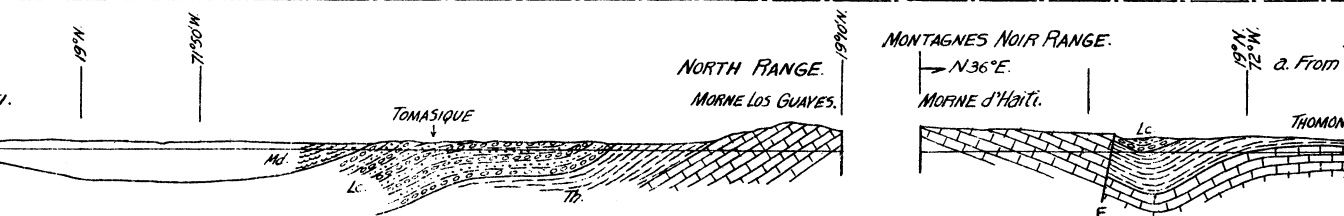
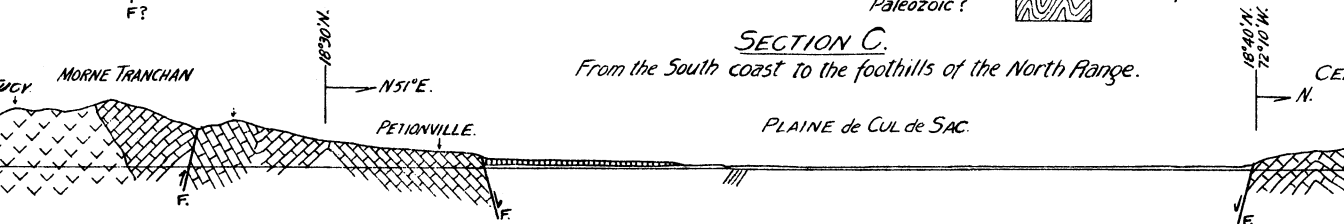
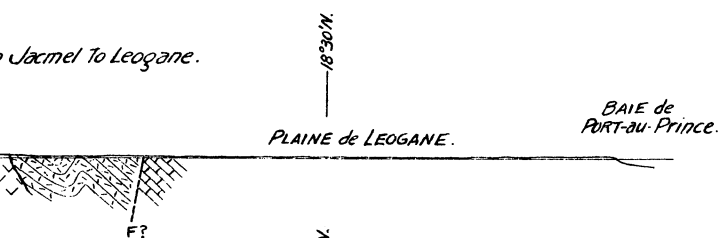
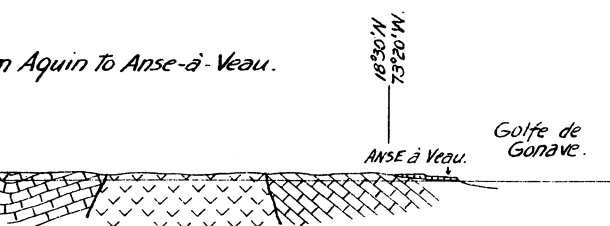
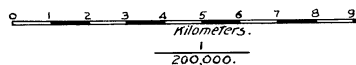
This series rests on the older complex and the unconformity is well exposed at several places along the south side of the north

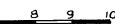
<sup>1</sup> L. G. Tippenhauer, *Die Insel Haiti*, Leipzig, 1893, p. 85.

<sup>2</sup> *Op. cit.*



# GEOLOGIC STRUCTURE SECTIONS





of 3.

*limestones.*

shales and marls.

sandstones and conglomerates.

*shales.*

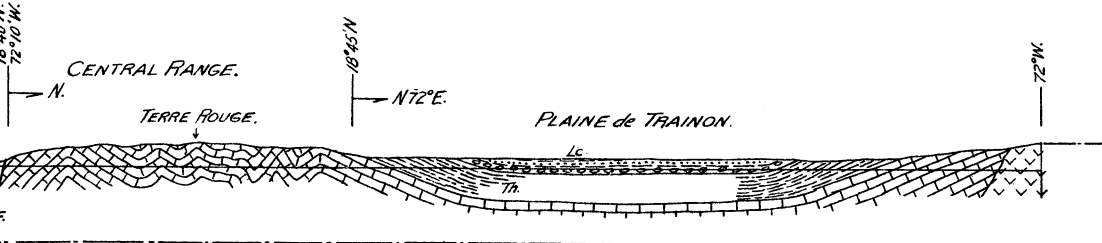


*Tertiary intrusive rocks.*



*Pre-tertiary intrusive rocks.*

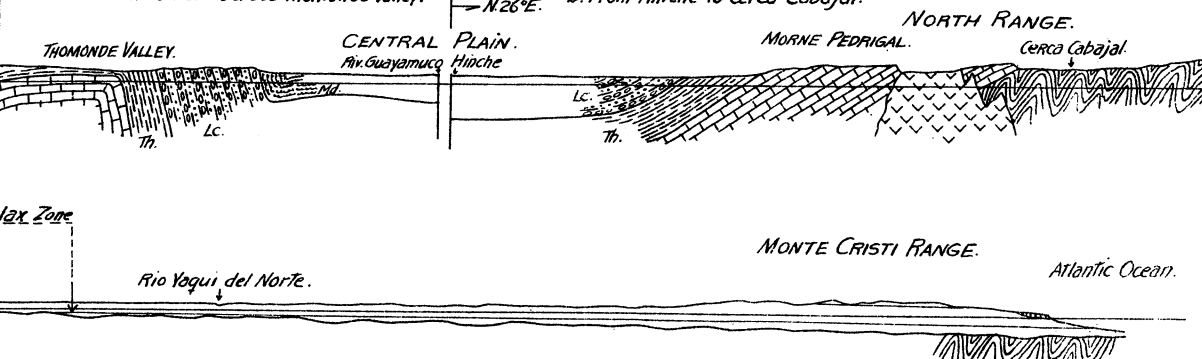
nd schistose rocks.



SECTION D.

72 a. From Morne d'Haiti across Thormonde Valley.

*b. From Hínche To Cerca Cabajal.*



# NS ACROSS HAITI.

9 10

Tones.

and marls.

stones and conglomerates.

s.

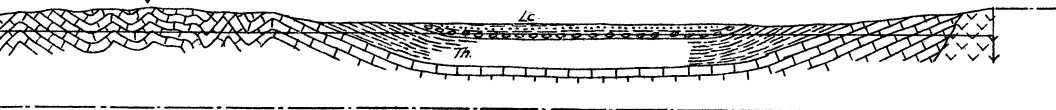
Tertiary intrusive rocks.

Pre-Tertiary intrusive rocks.

istose rocks.

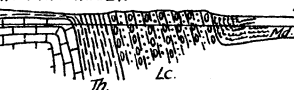
CENTRAL RANGE.

TERRE ROUGE.

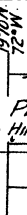


SECTION D.  
From Morne d'Haiti across Thomonde Valley.

THOMONDE VALLEY.



CENTRAL PLAIN.  
Riv. Guayamuco



b. From Hinche To Cerca Cabajal.

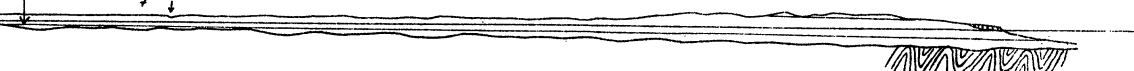


MORNE PEDRIGAL.

NORTH RANGE.

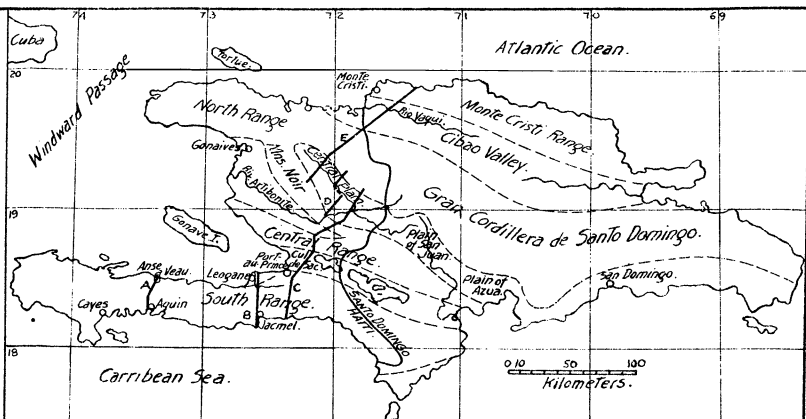
Cerca Cabajal.

Rio Yagui del Norte.



MONTE CRISTI RANGE.

Atlantic Ocean.



Sketch Map of the Island of Santo Domingo showing the major topographic divisions and the location of the structure sections.

range, especially near Cerca Carbajal. All along this range the prevailing dip is to the south.

Tippenhauer<sup>1</sup> in a section north of Gonaïves determined a thickness of 16,500 feet for this limestone series. There is probably duplication at this place. A section the writer measured between Hinche and Cerca Carbajal showed a thickness of 13,000 feet but later the conclusion was reached that there was good evidence here of duplication. There is, however, at least in this section, a

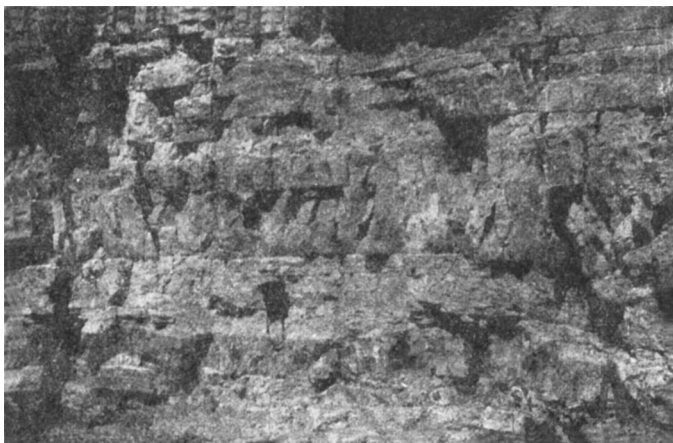


FIG. 1.—Fine-bedded, compact, foraminiferal limestone in quarry near Gonnaïves

thickness of about 6,000 feet exposed. Southeast of Port-au-Prince, on the road to Fucy there is, however, an unduplicated section of limestone whose thickness is at least 8,000 feet (see Plate V, Section C, south range).

This same limestone on the south side of the Gran Cordillera in Santo Domingo was called Cretaceous by Gabb,<sup>2</sup> being included by him with other limestone of undoubted Cretaceous age. Tippenhauer has called it Miocene and Pliocene and his mapping has been done largely on the basis of the color of the rock. The conclusion that it is Eocene and lower Oligocene, prior to any paleontological work, is based on its striking similarity to the Jamaica and Cuban occurrences and also because of its position relative to overlying

<sup>1</sup> *Peterm. Mill.*, Bd. 45 (1899), pp. 153-55.

<sup>2</sup> *Op. cit.*

sediments of known age in Haiti. The Oceanic series of Hill,<sup>1</sup> about 2,000 feet thick, corresponds in character to the Haitian series. Cuban occurrences are also similar.

Maury<sup>2</sup> has described the upper Oligocene-Miocene series in the Yaqui Valley of Santo Domingo and these same formations reach a great development in Haiti, where they overlie the limestone. In a section by Tippenhauer<sup>3</sup> he found none of this limestone on

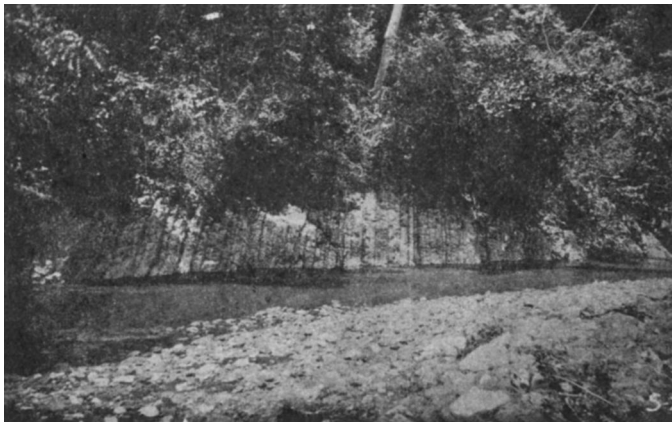


FIG. 2.—Foraminiferal limestone on Grand Rivière de Jacmel, south peninsula

the north side of the north range and likewise in Santo Domingo neither Gabb nor Maury mention this limestone north of the range. It is apparently entirely lacking on that side of the island. Hill<sup>4</sup> places a gap in middle Oligocene time between his Oceanic series and the Bowden of Jamaica, the latter of which corresponds to at least part of the Miocene of Maury's section in Santo Domingo. There is, however, no structural evidence of unconformity above the limestone in Haiti. Dips are generally concordant and where they are not there is evidence of faulting.

#### C. TERTIARY CLASTIC SEDIMENTS

*General.*—Overlying the Eocene-Early Oligocene limestones is a thick series of shales, marls, conglomerates, and sandstones. This

<sup>1</sup> *Bull. Mus. Comp. Zool.*, Harvard Coll., XXXIV, 1899.

<sup>2</sup> *Op. cit.*

<sup>3</sup> *Op. cit.*

<sup>4</sup> *Op. cit.*

series underlies the entire central plain of Haiti and another area south of Mirebalais and probably underlies much of the lower valley of the Artibonite River. The beds are well exposed and are folded, highly in places, especially along the west side of the central plain, so that good sections can be seen. The whole series is very thick, perhaps as much as 10,000 feet, and is, in places, extremely fossiliferous. Some small amount of detailed work was done on these rocks and some fossils collected, though the work as yet is



FIG. 3.—Las Cahobes beds near Las Cahobes

by no means systematic. The writer expects to present further notes on this series in the near future.

Referring to the central plain area, these beds occupy a broad syncline. All along the foothills of the north range, on the east side of the plain, the beds dip southwest at varying degrees up to  $35^{\circ}$ , and as far as noted the dips are concordant with the dip of the underlying limestone. On the west side of the plain the structure is complicated by sharp flexures and in many places the contact with the underlying limestone is one of faulting.

South of Hinche in the vicinity of Thomonde an asymmetric anticline strikes off the Montagnes Noires Range in a southeasterly direction and from this vicinity on to the southeast the structure underlying the plain is that of two broad synclines with the

Thomonde anticline, which becomes broad and symmetrical, in the middle and forms the dominant feature of the structure. Along the north flank of the central range the contact between this series and the underlying limestone is probably a fault.

The northern part of this plain is very flat and grass-covered. Going south there is a progressive increase in the erosional dissections and excellent sections are exposed in the several large streams north and west of Maissade. East of Hinche along the River Samana, on the road from Hinche to Las Cahobes, and in the southerly portion of the plain in general well-exposed sections are numerous.

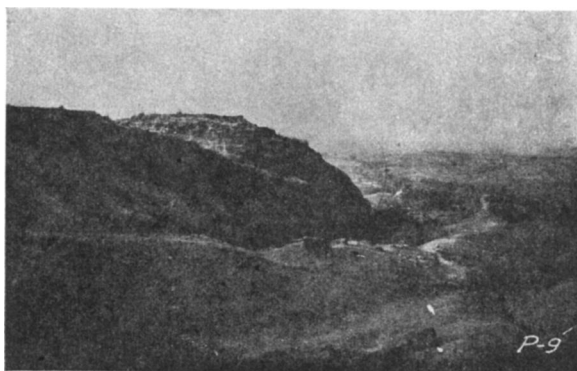


FIG. 4.—Las Cahobes beds rising above level of the plain, east of Las Cahobes

Limestone fragments have not been noted as entering into the make-up of the beds. The material is derived almost entirely from the old Paleozoic series and the igneous rocks associated with it.

*Divisions.*—In Haiti for the purpose of facilitating structural delineation the writer divided this series of sediments into three divisions, purely on a lithologic basis. The distinction holds wherever the series is exposed.

#### 1. *Lower—Thomonde Beds*

The lowest division, called the Thomonde beds, consists almost entirely of fine-grained sediments, chiefly fine, bluish, soft shales. The thickness of this member varies and it seems to be thinner along the eastern side of the central plain. Its maximum thickness

may be 1,500 feet. It is fossiliferous to some extent but no collections were made from it.

2. *Middle—Las Cahobes Beds*

The middle division, called the Las Cahobes beds, is quite different. It consists of coarser and more consolidated rocks. In



FIG. 5.—Maissade beds on Rio Blanco near Maissade. Protruding bed is composed of *Scapharcas*.

general this member may be described as an alternating series of conglomerates, which are quite hard, with pebbles usually smaller than a robin's egg; sandy shales; some beds of coarse, unconsolidated sands; thin beds of very hard sandstone which characteristically weather out to flat rounded knobs; some limy beds, and at

some places coral limestones (Figs. 3 and 4). Also characteristic of this division are several beds composed mostly of a very thick large species of *Ostrea*. In other beds are myriads of *Scapharcas*. This division is quite fossiliferous, the conglomerate members and many of the sandstone beds, however, being generally devoid of fossils. No complete collections were made but the following species have been recognized:

#### LAS CAHOBES FOSSILS

##### LOCALITY: HILL SOUTH OF THOMONDE

*Conus* sp.  
*Cornus stenostomus* Sowerby  
*Drilla riogurabonis* Maury  
*Fasciolaria kempi* Maury  
*Phos gabbi* Dall  
*Meta perplexabilis* (?) Maury  
*Murex domingensis* Sowerby  
*Aspella scateroides* Blainville  
*Strombus maoensis* Maury  
*Turritella planigyrate* Guppy  
*Turritella tornata* Guppy  
*Solarium quadriseriatum* Sowerby  
*Polinices stanislas-meenieri* Maury  
*Sinum nolani* Maury  
*Scapharca chiriquiensis* Gabb<sup>1</sup>  
*Scapharca quayubinica* Maury  
*Scapharca cercadica* Maury  
*Ostrea gilbertharrisi* var.<sup>2</sup>  
*Venericardia scabriocstata* Guppy  
*Echinochama antiquata* Dall  
*Ostrea megodon* Hanley  
*Pecten engrammatus* (?) Dall  
*Pecten hatoviejonis* Maury  
*Pecten soror* Gabb  
*Phacoides (Mitha) smithwoodwardi* (?) Maury  
*Cardium (Trachycardium) dominicanum* Dall  
*Tellina (Scissula) cercadica* (?) Maury  
*Tellina cibaoica* Maury  
*Mytilopsis domingensis* Reeluz  
*Siliqua subaequalis* Gann

<sup>1</sup> Occurs in massive beds.

<sup>2</sup> Occurs in massive beds, very much more elongated than Maury's species.

This middle division (Las Cahobes) is very thick. On the road from Hinche to Thomonde these beds are tilted to angles of from  $75^{\circ}$ – $85^{\circ}$  and the total thickness exposed is probably over 6,500 feet.

Excellent exposures of this divisions occur at many place and there are some especially interesting localities near Las Cahobes.

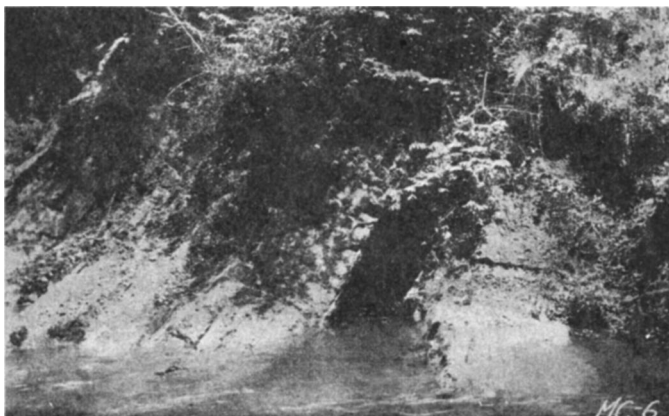


FIG. 6.—Maissade beds on Rio Blanco, showing bed of lignite

### 3. *Upper—Maissade Beds*

The uppermost division of this series consists of shales, marls, and some sandstones and is characterized by lignitic beds which near the town of Maissade are well defined. The division is well exposed north and west of Maissade along the Rivière Canot and its several branches, notably the Rivière Fond-de-Gras, Rio Piedre, and Rio Blanco. An excellent section is obtainable on the Rio Blanco of that part of the division containing the lignite beds (Figs. 5 and 6). Following is a detail of this locality and a list of the fossils hastily collected from it:

#### DETAIL SECTION ON RIO BLANCO

	FEET
Lignite, brown, flaky . . . . .	6.5
Marl, gray, argillaceous . . . . .	6.5
Sandstone, hard, gray . . . . .	0.6
Sandstone, shaly, with masses of <i>Arcas</i> in lower part and <i>Ostreas</i> in upper part . . . . .	3.5

	FEET
Clay, blue . . . . .	0.6
Lignite, shaly and flaky. . . . .	0.7
Sandstone, gray, lignitic streaks. . . . .	5.0
Shale, with flaky lignite. . . . .	3.5
Shale, gray, sandy. . . . .	0.3
Clay, gray, lignitic streaks, very fossiliferous. . . . .	4.5
Shale. . . . .	3.3
Sandstone, fossiliferous. . . . .	0.3
Lignite, shaly and flaky. . . . .	1.2
Lignite. . . . .	0.8
Sandstone, shaly, hard, fossils near top. . . . .	0.8
Shale, black, carbonaceous. . . . .	1.8
Clay, sandy, gray, fossiliferous. . . . .	0.6
Clay, blue, very fossiliferous. . . . .	10.5
Clay, blue, <i>Ostrea</i> bed. . . . .	3.3
Clay, blue, small fossils, <i>Turritella</i> , <i>Ostrea</i> absent. . . . .	4.5
Clay, blue, <i>Ostrea</i> bed with <i>Arcas</i> and other shell fragments. . . . .	6.0
Clay, blue, <i>Turritella</i> bed. . . . .	7.2

#### MAISSADE FOSSILS

##### LOCALITY: RIO BLANCO NORTH OF MAISSADE

*Phos gabbii* Dall  
*Melongena consors*  
*Phos costatus* Gabb  
*Potamides Roumaini* Pillsbury<sup>1</sup>  
*Potamides caobensis* Pillsbury<sup>1</sup>  
*Turritella planigyrate* Guppy  
*Turritella tornata* Guppy  
*Niso grandis* Gabb  
*Scapharca chiriquiensis* Gabb<sup>2</sup>  
*Scapharca cor-cupidonis* Maury  
*Ostrea virginica* Gmelin  
*Lucina chrysostoma* Philippi  
*Mytilopsis domingensis* Recluz

This division is particularly rich in fossils. The writer visited a locality on the Rivi re L'Ayaye about twelve kilometers northwest of Las Cahobes to examine a lignite deposit. The lignite

<sup>1</sup> Very abundant, not noted in Maury's Santo Domingo section.

<sup>2</sup> Massive bed, see Fig. 5.

proved to be merely lignite fragments imbedded in sand. The exposure is a bluff on the east of the river and consists largely of shale beds dipping east at low angles. Pieces of the shale lay about the base of the bluff and from these pieces the following species were collected:

## FOSSILS FROM MAISSADE BEDS ON RIVIERE L'AYAYE

*Bullaria paupercula* Sowerby  
*Terebra berlinerae* Maury  
*Conus ritteredgei* Maury  
*Conus symmetricus* Sowerby  
*Conus* sp.  
*Turris albida barretti* Guppy  
*Turris albida virgo* Lam.  
*Drillia fusiformis* Gabb  
*Drillia consors* Sowerby  
*Drillia henekeni* Sowerby  
*Glyphostoma dentifera* Gabb  
*Glyphostoma golfoyaquensis* Maury  
*Oliva cylindrica* Sowerby  
*Olivella muticoides* Gabb  
*Marginella maoensis* Maury  
*Marginella (Persicula) cercadensis* Maury  
*Fusus henekeni* var (?)  
*Mitra henekeni* Sowerby  
*Latirus fusiformis* Gabb  
*Vasum hiatense* Sowerby  
*Melongena consors* Sowerby  
*Phos costatus* Gabb  
*Phos fasciolatus* Dall  
*Metula cancellata* Gabb  
*Strombina prisma* P. & J.  
*Murex messorius* Sowerby  
*Murex domingensis* Sowerby  
*Murex (Chicoreus) cornerectus* Guppy  
*Typhis cercadicus* Maury  
*Cassis sulcifera* Sowerby  
*Malea camura* Guppy  
*Cypraea spurcoides* Gabb  
*Strombus proximus*  
*Strombina divilitus* H. & M. (?)  
*Cerithium russelli* Maury  
*Siliquaria gurabensis* Maury

*Turritella planigyrate* Guppy  
*Natica (stigmaulas) sulcata* Born  
*Amauropsis guppyi gurabensis* Maury  
*Neretina (Smaragdia) viridemaris* Maury  
*Neretina* sp.  
*Astraliuim karlschmidti* Maury  
*Callisotoma grabaui* Maury  
*Melanella (Eulima) cercadica* Maury  
*Dentallium dissimile* Guppy  
*Potamides caobensis* Pillsbury  
*Scapharca guayubunica* Maury  
*Scapharca henekeni* Maury  
*Scapharca (Cunearca) willardausteni* Maury  
*Scapharca losguemadica* Maury  
*Scapharca hispaniolana* Maury  
*Pecten cereadica* Maury  
*Lucina chrysostoma* Philippi  
*Phacoides (Miltha) smithwoodwardii* Maury  
*Cardium (Trachycardium) tintinabularum*  
*Tellina islahispaniolae* Maury  
*Mytilopsis domingensis* Recluz  
*Corbula (Cuneocorbula) dominicensis* Gabb  
*Corbula (Cuneocorbula) caimitica* Maury  
*Euspamia* sp.  
*Madrapore* sp.

The Las Cahobes member of this series has resisted erosion to a greater extent than the members above or below it. Hence there is a generally well-defined valley or depression skirting the edge of the plain in its lower part which is underlain by beds of the lower or Thomonde division. The Las Cahobes beds stand above the general level of this plain and, where tilted, form hills parallel to its border (Fig. 7). Along the eastern and southern sides of the plain these hills are prominent and where the beds are nearly vertical sharp ridges are formed by the harder members, chiefly the conglomerates. Pine trees grow in the central plain but are confined to the areas of Las Cahobes rocks.

The foregoing notes will explain why the division of the series was made. It may not stand from a paleontologic viewpoint. It will prove useful, however, in future work and makes delineation of structure fairly simple.

*Age and correlation.*—On the general correlation table these sediments are shown in part as Oligocene and Miocene to correspond with Maury's determinations in the Yaqui Valley of Santo Domingo. What is here called the Maissade is undoubtedly the equivalent of the *Sconsia laevigata* and the *Aphera islacolonis* formations in Maury's section<sup>1</sup> and the equivalent in part of Hill's Bowden in Jamaica. This places the Maissade in the Miocene and it represents probably lower and middle Miocene. This being the case,



FIG. 7.—Hills formed by upturned Las Cahobes beds near Las Cahobes

at least the upper part of the Las Cahobes beds are the equivalent of the *Orthaulax inornatus* formation of the Yaqui section, which Maury places in the Oligocene. In general lithologic characters the beds so far correspond well to the Santo Domingo section, and while the work so far done in Haiti along paleontologic lines is merely the result of a few minutes collecting here and there, nevertheless there is a striking similarity in faunas, sufficient no doubt to make the correlation definite.

According to Gabb<sup>2</sup> the entire thickness of the lower members including the *Orthaulax inornatus* is only 600 feet. It seems evident that the entire section is not developed in Santo Domingo and that in Haiti the larger part of the entire thickness of sediments lies

<sup>1</sup> *Op. cit.*

<sup>2</sup> *Op. cit.*, p. 95.

TABLE I  
CORRELATION TABLE OF THE EOCENE, OLILOCENE, AND MIOCENE FORMATIONS OF THE ANTILLES

Jamaica (Hill)	Cuba (Vaughan)	Santo Domingo (Maury)	Haiti (Jones)		
	La Cruz Marl	Upper horizon of Maury ( <i>Sconsia laevigata</i> )			Middle
Bowden	Marl at Baracoa	Zones G, H, & I of Maury ( <i>Aphera islacolonia</i> )	Maissade beds 1,000' +		Lower
	Anguilla	<i>Orthaulax</i> zone			Upper
(Missing)	Coral reef at Guantanamo	(Missing on north side)	Las Cahobes beds 6,500'		Middle
	(Missing)		Thomonde beds 1,500'		-----
Oceanic series		(Present on south side)	Limestone series 8,000' +		Lower
	St. Bartholomew limestone				Upper
					Eocene

NOTE.—----- indicates position of divisional line doubtful.

below anything yet described in the Antilles. Below the *Aphera islacolonis* formation of Maury we are dealing with formations which are absent in Jamaica, and below the *Orthaulax inornatus* and underlying beds of Santo Domingo we are dealing with formations which have probably not been encountered elsewhere in the Antilles.

Limestones and marls of upper Oligocene age are widespread in Cuba and only two isolated and local formations occur there which may be of early Oligocene age and both of these are doubtful.<sup>1</sup>

Berkey<sup>2</sup> places his Arecibo formation of Porto Rico as extending through Oligocene and Eocene but Maury<sup>3</sup> believes that it will prove to be the equivalent of the Santo Domingo section. Vaughan's<sup>4</sup> correlation table shows the "Pepino," of Porto Rico, equivalent to the lower horizon in Santo Domingo, which is middle Oligocene. In Jamaica, then, the middle and upper Oligocene are missing. In Cuba the upper, in Porto Rico the middle, and in Santo Domingo both upper and middle, Oligocene are present. It is thought, at least from Hill's description, that the entire Oceanic series (limestones) of Jamaica is present in Haiti. If this is true then either the lower horizon in Santo Domingo does not occupy all of middle Oligocene time or the Oceanic series of Jamaica does not extend to middle Oligocene; for in Central Haiti, between the two and forming a conformable series, is a large thickness of sediments which is apparently absent elsewhere in the Antilles.

#### RELATIONS OF EOCENE-EARLY OLIGOCENE LIMESTONES AND OLIGOCENE-MIOCENE SEDIMENTS

The foregoing notes will indicate a stratigraphic problem of some interest. First, in Haiti there is a thick series of sediments of Oligocene-Miocene age in which the lower and major part is confined to the Oligocene, and this part has apparently not been noted or described heretofore. Secondly, this series rests apparently

<sup>1</sup> Bailey Willis, "Stratigraphy of North America," *U.S. Geol. Survey, Prof. Paper* 71, 1912, p. 722.

<sup>2</sup> *Op. cit.*, p. 29.

<sup>3</sup> *Op. cit.*, Bull. 30, p. 41.

<sup>4</sup> T. W. Vaughan, "Correlation of Tertiary Geological Formations of Southeastern United States, Central America and the West Indies," *Washington Acad. Sci., Proc.*, VIII, 1918, 268-76.

conformably on a series of deep-water limestones which extend through late Eocene and into early Oligocene. Thirdly, the Santo Domingo equivalents of the upper part of the Miocene-Oligocene series in the Yaqui Valley rest directly on the Paleozoic complex and the limestone series is lacking. Fourthly, in Jamaica there is a well-defined break in middle Oligocene time between the two. These relationships would point to an unconformable relationship between the two which in the Haiti section, since dips are concordant, would be a disconformity. The fact that the upper series is so thick below the late Oligocene, together with the fact that these beds contain no material derived from the limestone, and also from the fact that the limestones do not occur on the north side of the range, would seem to indicate that no unconformity exists in the Haiti section and that this set of conditions can be explained only in one way. The thick oceanic limestones were apparently formed against a coast off which there was an abrupt drop to deep water and this coast line lay across Haiti from southeast to northwest about on the line of the north range. The limestone would then be deposited in the form of abrupt overlap to the north. Uplift, which was sufficient to bring the limestone above the sea elsewhere, left it along this shore still below sea-level so that the later sediments (Thomonde, etc.) were laid down conformably on it. Gradual depression brought about overlap of these later sediments and the Santo Domingo section was deposited.

#### THE TERTIARY SERIES OF THE SOUTH PENINSULA

The foregoing notes apply chiefly to that part of Haiti north of Port-au-Prince and the Cul-de-Sac depression between the central and south ranges. The writer's observations on the south peninsula have been chiefly confined to following out in a general way Tippenhauer's sections<sup>1</sup> and modifying in some cases his interpretations of structure.

The probability of Cretaceous formations in this region have been previously noted. The Tertiary series is in general the same as in the northern part of Haiti but there seems to be a modification which points to a closer similarity in lithologic characters to the

<sup>1</sup> *Op. cit.*, Bd. 45, pp. 25-29, 201-4; Bd. 47, pp. 169-78.

Jamaican occurrences. This is not, of course, surprising in view of the fact that Jamaica is but a continuation of this peninsula.

The Eocene–Early Oligocene limestones are generally more finely bedded than in the central and north ranges of Haiti. The overlying Oligocene–Miocene series is represented in part in several localities—the L’Asile Valley and north of Aux Cayes, in both of which are found lignite deposits.

Near Jacmel on the south coast is a formation of conglomerate and marls and limestones which unconformably overlie the earlier

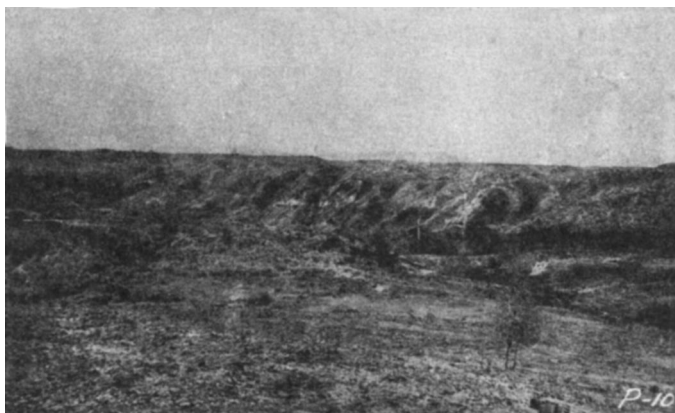


FIG. 8.—View of central plain of Haiti with Montagnes Noires in the distance

limestones and in the case of the conglomerates are largely composed of them. These beds are well stratified, are folded, and unconformably underlie the oldest elevated coral reefs (see Plate V, Section B). These beds may possibly be the equivalents of the Pliocene series of Jamaica (Manchioneal).<sup>1</sup>

#### LATE TERTIARY AND QUATERNARY DEPOSITS

*Pliocene (?) beds of the central plain.*—In the southerly part of the central plain of Haiti and resting upon the eroded edges of the Oligocene–Miocene sediments is a series of gravels and sands devoid of marine fossils. These beds, in distinction to the underlying series, contain many, and often well water-worn, boulders of limestone (Fig. 8). Chert nodules from the foraminiferal limestones are

<sup>1</sup> Hill, *op. cit.*, p. 86.

very plentiful and the beds contain numerous fragments of petrified wood, often whole trunks of trees. Many of the sands are well cross-bedded. There is physiographic evidence to show that the region, after uplift and folding, drained to the southeast through Santo Domingo across what are now the plains of San Juan and Azua. Before the deposition of these non-marine beds the region suffered considerable erosion, perhaps through Pliocene time, for these beds, which the writer has called the Hinche beds, fill many old erosion gullies in the underlying folded earlier series. Drainage



FIG. 9.—South side of central plain east of Las Cahobes. Sharp hills formed by Las Cahobes beds.

was then cut off and the region became a lake in which the Hinche beds were deposited. The floor of this lake is formed by the uppermost Hinche beds and that old floor, intact in the northern part of the plain, and largely eroded away in the southern part (Fig. 8), forms the surface of the central plain above which stand the Las Cahobes beds (see Fig. 9).

*Terrace deposits.*—The southern part of the central plain region is terraced (see Fig. 10) and on these terraces are loose gravels. At least four terrace levels are noted. After the deposition of the Hinche lake beds an opening was cut through the limestone range south of Las Cahobes and the plain region drained that way, the rivers following the Artibonite in its lower valley. This old cut

through the high range and through the hills of Las Cahobes beds north of that place is very distinctive.

Successive uplift and periods of quiescence brought about the terracing of this region and the dissection of the plain. Erosional remnants standing as high as the old surface are numerous. Apparently only recently has the Artibonite River passed out of the plain region through the Montagnes Noires farther west.

*Elevated coral reefs and marginal deposits.*—The same successive elevations and periods of quiescence which brought about the



FIG. 10.—Terraces of the central plain

terracing of the central plain region has also terraced the coast, a well-known feature of the islands of the Antilles. On many of these terraces are coral reefs and marginal sands, while coral débris is common. Near St. Marc is an elevated deposit which contains innumerable specimens of *Strombus gigas*.

#### IGNEOUS ROCKS

##### SYENITE-GRANITE

The igneous rocks of Haiti present quite a range from almost a true granite to basalt. The oldest igneous rocks are the more acid, the youngest the more basic.

The oldest rocks are the syenites and granites which occupy the large areas or belts more or less parallel with the axis of the

north range and as far as noted found only in that range. These rocks are intrusive into the old complex and their age is, therefore, indeterminate. The same rocks occur in Cuba and associated with them there are serpentines. Serpentines have not been noted in Haiti. The larger masses of these syenites and granites are fairly even-grained in texture while the smaller bodies and dikes which cut the surrounding rocks in numerous places are porphyritic. As far as known no petrographic descriptions of these rocks from Haiti have been published.

There may be still older igneous members in the Paleozoic complex but the occurrence has not been noted.

#### QUARTZ-DIORITE

In the region north and northwest of Gonaïves are intrusions of quartz-diorite. These intrusives cut through the foraminiferal limestone series which is generally totally recrystallized along the contacts; and locally occur contact metamorphic deposits with the usual contact minerals, garnet, calcite, chalcopyrite, magnetite, pyrite, bornite, etc.

The age of the quartz-diorite intrusion is probably late Miocene and apparently took place at the time of general uplift and folding which followed the deposition of the middle Miocene sediments.

#### ANDESITES

Younger and cutting through the quartz-diorites are andesites. There also occur the associated andesitic flows and breccias. While these rocks are probably associated with the same general period of igneous activity as the quartz-diorites, nevertheless the flow materials often occupy erosional depressions in the underlying rocks. Andesitic rocks occupy large areas in Haiti. The intrusive phase of the rock is somewhat variable in appearance.

#### BASALTS

Basalts occur at several places. There are basaltic flows from probable fissure eruptions along the northern side of the salt lakes in the Cul-de-Sac depression near Port-au-Prince.

Between the Cul-de-Sac depression and Ville Bonheur (Saut d'Eau) is a well-defined crater from which extend basalt flows. These flows occupy depressions in the present topography and have not been since modified by erosion other than the removal of fine loose material leaving along the edges of the flows loose blocks of the volcanic rock resting on underlying formations. These rocks are very recent and were poured out during one of the last eruptions in Haiti.

Deposits of volcanic ash occur at numerous places, and it is said that one or more cinder cones are located near the coast on the south side of the north peninsula.

#### GEOLOGIC STRUCTURE

The structure sections shown herewith are composite sections based on Tippenhauer's work and the writer's observations. The profiles are only generally correct. The sections covering the south peninsula are based on Tippenhauer's mapping with certain modifications of his interpretations. While the writer has crossed this peninsula in two places his trips were very hurried and the thick vegetation prevented him from taking more than very casual notes. From the Cul-de-Sac plain north to the foothills of the north range the section is largely the writer's, especially the part covering the central plain. The several sections across the plain are the writer's and the section across the north range is somewhat imaginary, though it does illustrate conditions in that region. The last part of the section is in Santo Domingo across the Yaqui Valley and the Monti Cristi Range and is generalized. It is inserted to show the relationships of the Oligocene-Miocene formations there to the equivalent formations of the central plain of Haiti.

The structure across the central plain region shows generally sharp flexing of the Oligocene-Miocene series along the western side of the plain, while the underlying limestones are generally faulted by thrust faults of some displacement. The sharp flexures in the later sediments are doubtless faults in the limestone beneath. A large fault is indicated well up on the south range of Haiti, a well-marked depression extending east and west along the course of this fault.

The peculiar depression between the south and central ranges is apparently a normally faulted block. The structure of this block is unknown. At only one point are the underlying rocks uncovered and here what are undoubtedly Oligocene-Miocene sediments are tilted at high angles. The indications are that this plain is a region similar to the central plain of Haiti, which was down-faulted to below sea level and has only been in part lifted above the sea in Pleistocene or Recent times. This is indicated by elevated coral reefs near Port-au-Prince.